UNDERGROUND INUNDATION BY PLUVIAL FLOOD IN FULLY URBANIZED AREA OF OSAKA

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1. INTRODUCTION

Frequency of local short-time heavy rain in urban areas is increasing recently. In urban areas, rainwater drainage depends on sewerage due to the increase in impervious areas. In addition, using underground spaces such as underground malls and subways are progressing to make effective use of space. When local heavy rainfall happens in a short time, not only pluvial flooding but also the risk of underground inundation increases. Terada et al. has investigated how the intruding water spreads across the subway network due to pluvial flood. From the result, flooded water has broadly spread across in the subway network. In our previous studies, inundation simulation by pluvial flood hasn't been done for other areas except the Ebie treatment area in Osaka City. In this study, a simulation model of InfoWorks ICM considering sewerage drainage system in the Tsumori treatment area which connect to the Ebie treatment area by subway tracks is built. Also, the inflow characteristics through the underground entrances in the Tsumori treatment area are discussed.

2. STUDY AREA AND METHOD

The study area shown in Fig.1 is Tsumori treatment area in Osaka city. The underground entrances are 261 in the subway (31 stations), 71 in the underground mall (3 places), and 27 in the underground parking lot (10 places). There are also 5 underpasses. The ground level flooding and the inflow through the underground entrances are calculated by InfoWorks ICM. This model is using 1D-2D urban drainage model. Floodwater flows only on roads and do not flows into residential areas such as buildings. Figure 2 shows the rainfall. The total rainfall is 242.0mm, and the rainfall exceeding 60mm/hr which is the sewer drainage capacity of Osaka City is 98.5mm.

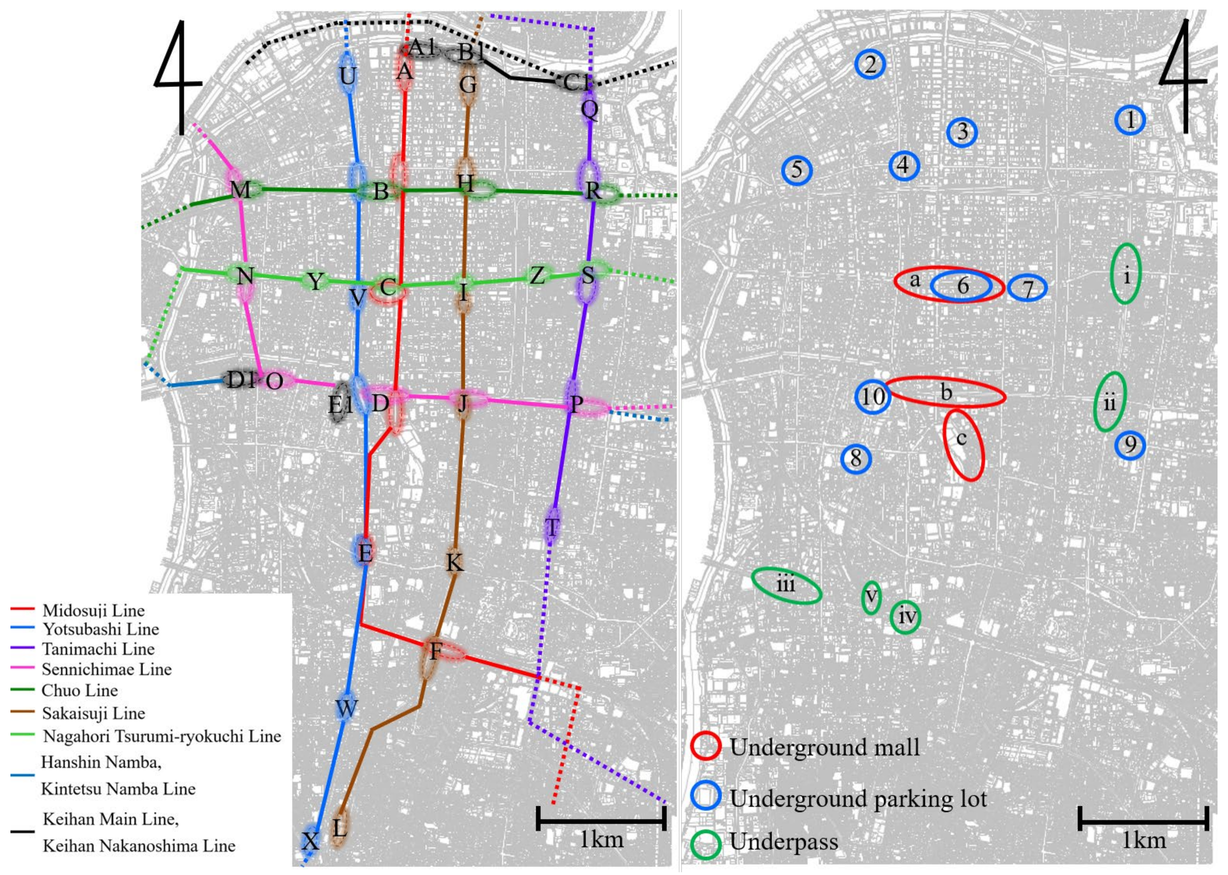

Fig.1 Tsumori treatment area in Osaka City
(left: subway network, right: other space)

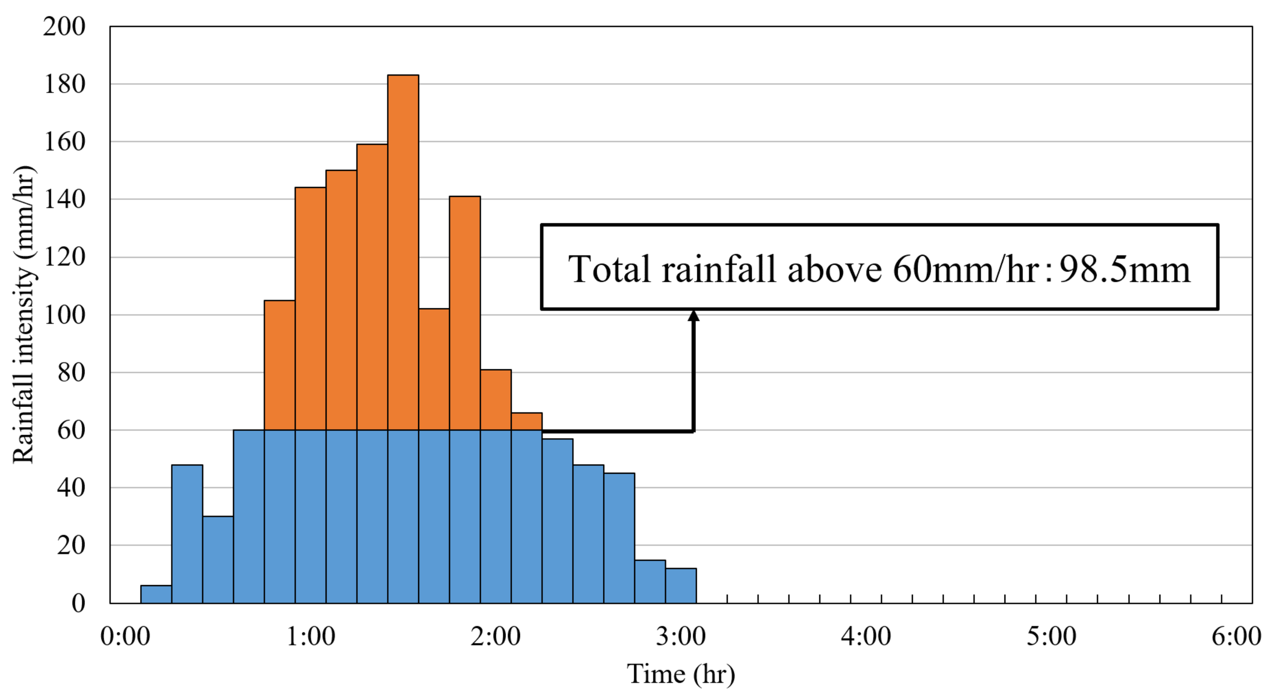

Fig.2 Subject rainfall hyetograph

3. GROUND LEVEL INUNDATION

Figure 3 shows the process of pluvial flooding and the maximum depth of inundation. The maximum inundation area only on the road was about 443ha. About 80% of the roads were flooded. The entire area was flooded at 2 hours from the start of rainfall. The inundation depth was more than 1m in the northern, northwestern, western, central southern and southwestern areas. 3 hours after, the ground inundation showed a peak. This peak time is about 1.5 hours after rainfall peak.

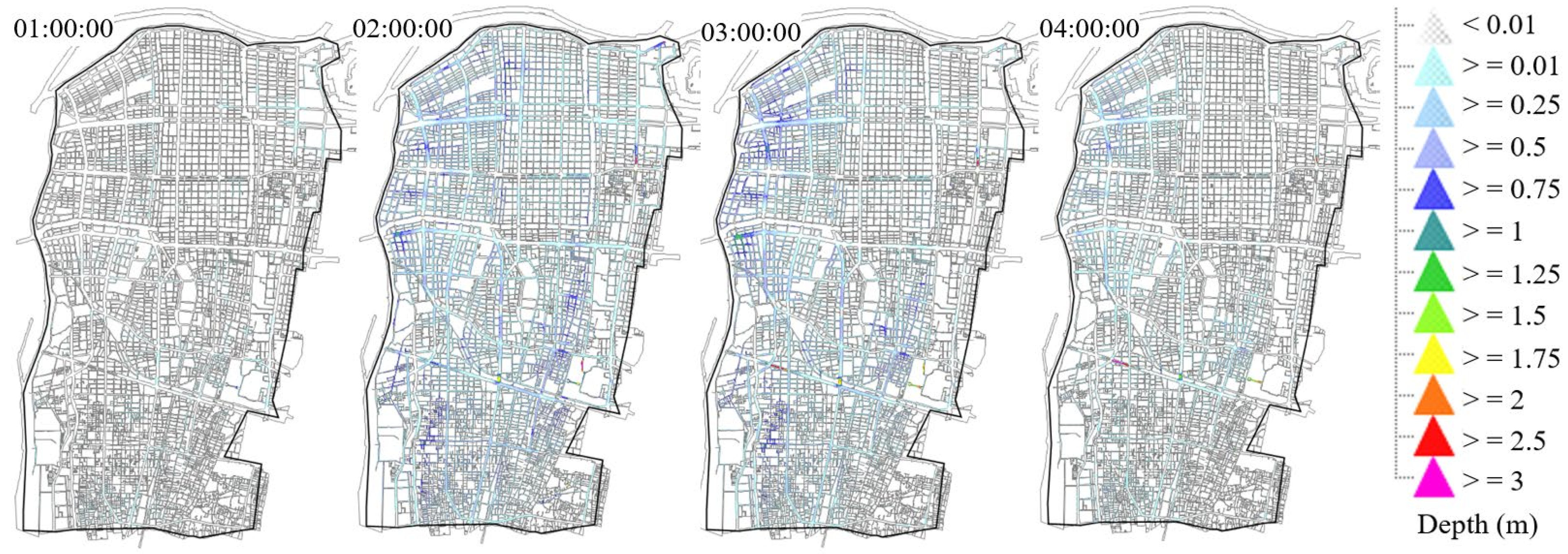

Fig.3 Inundation process and maximum depth

4. INFLOW CHARACTERISTICS INTO UNDERGROUND SPACE

The results show that, 24 subway stations were flooded. Inflow occurred at 84 entrances, and the total inflow into the station was 280,123m^3. The top six stations with the largest inflows accounted for 74% of the total. Figure 4 shows the inflows at the six. At Awaza Station, Nishinagahori Station and Sakuragawa Station, the inflow peak was about 50 minutes behind other stations. The area around 3 stations is below or less than 1m above sea level, thus peak time was slowed by floodwater flowing from other areas. Figure 5 shows the inundation depth of underpass. If a car is submerged, the escape limit depth for adult men is 0.56m (Takahashi et al,2013). At the underpass, the water depth exceeded the escape limit water depth in about 50 minutes from the start of rainfall. Therefore, it is suggested that early evacuation during inundation becomes important in underpass.

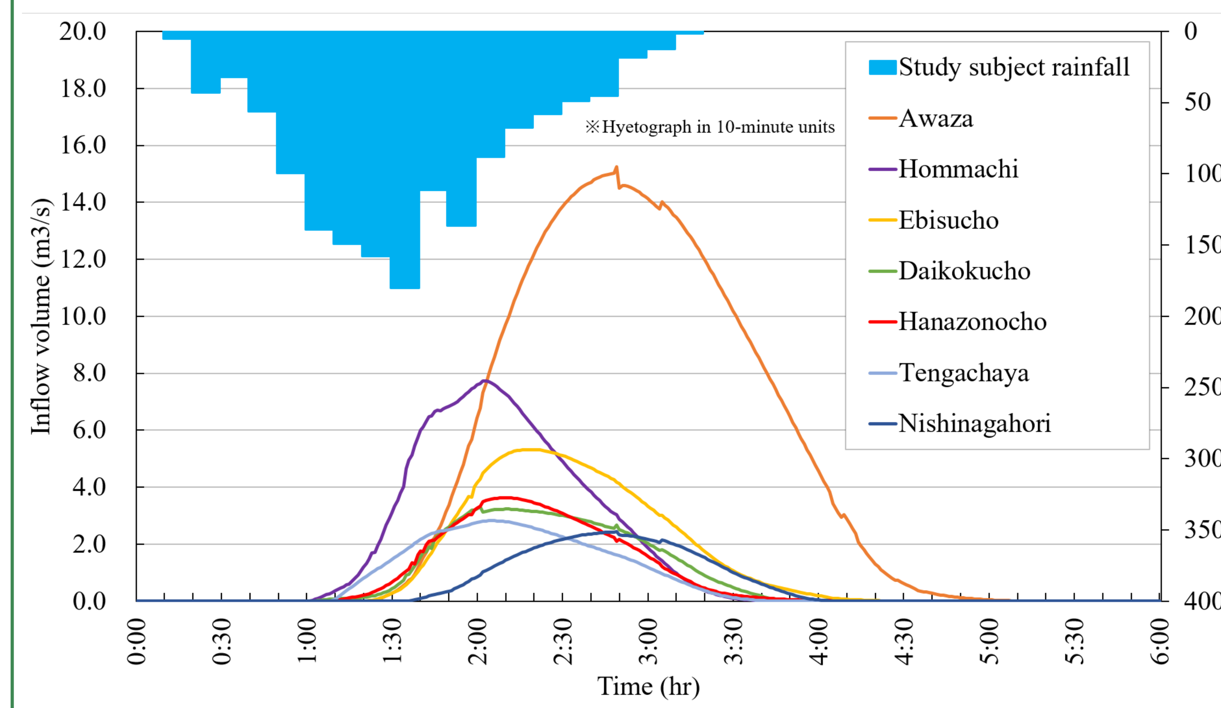

Fig.4 Inflow to subway stations

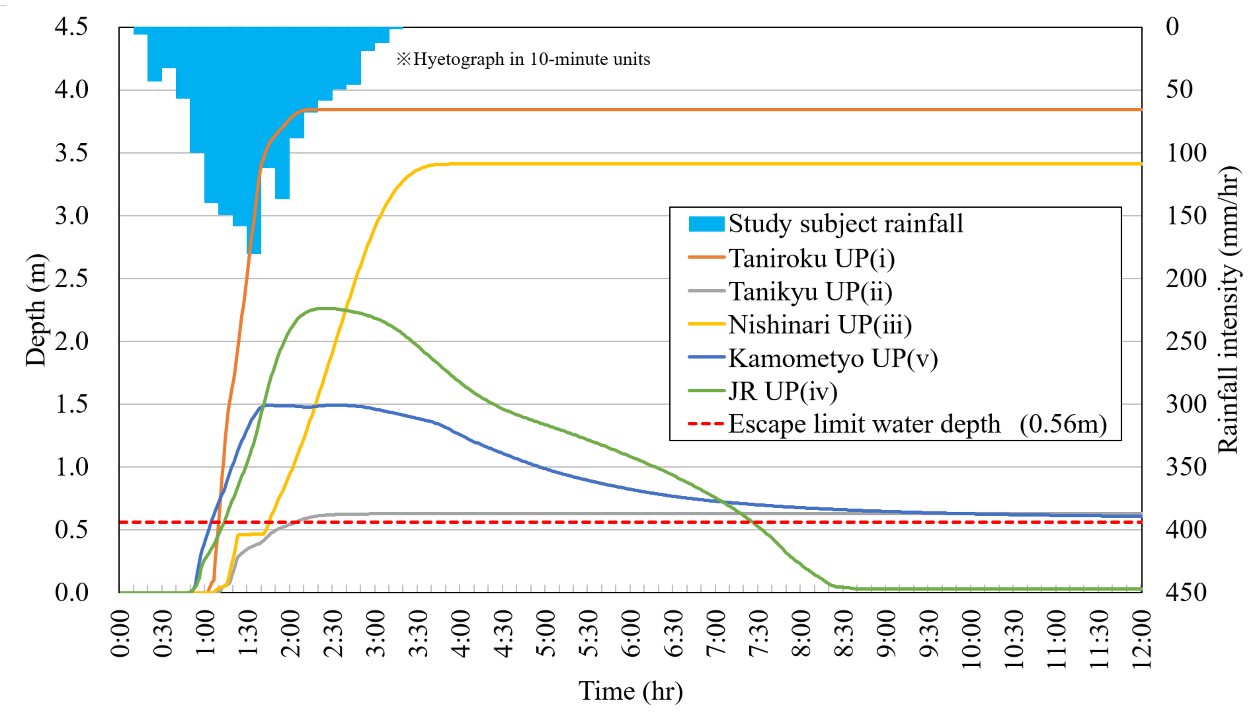

Fig.5 Inundation depth of underpass

5. CONCLUSIONS

In this paper, a simulation model considering sewerage drainage system in Tsumori treatment area in Osaka city was built. Underground entrances were modeled on the basis of field survey results. Numerical results show that the inflow rate of the flood water was 6.04% in subway, 0.04% in underground mall, 1.57% in underground parking, and 0.48% in underpass.

REFERENCES

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- Terada, M., Okabe, R., Ishigaki, T., Ozaki, T., and Toda, K. (2016), Subway inundation by pluvial flooding in densely urbanized area, Journal of Japan Society of Civil Engineering, B1(Hydraulic Engineering), Vol.72, No.4, I_1357-I_1362. (in Japanese)